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ABSTRACT

This first in a series of six modules for a course titled Civil/Structural Inspection describes engineering and construction activities associated with the construction of a nuclear power plant. In addition, the module describes the equipment and materials used and some of the inspection operations which may be performed by the quality assurance/quality control technician. The module follows a typical format that includes the following sections: (1) introduction, (2) module prerequisites, (3) objectives, (4) notes to instructor/student, (5) subject matter, (6) materials needed, (7) procedures, (8) data table, (9) reference materials, (10) test. (The course is one of fifteen technical courses for the second year of a two-year postsecondary curriculum in Nuclear Quality Assurance/Quality Control Technology.) (LRA)

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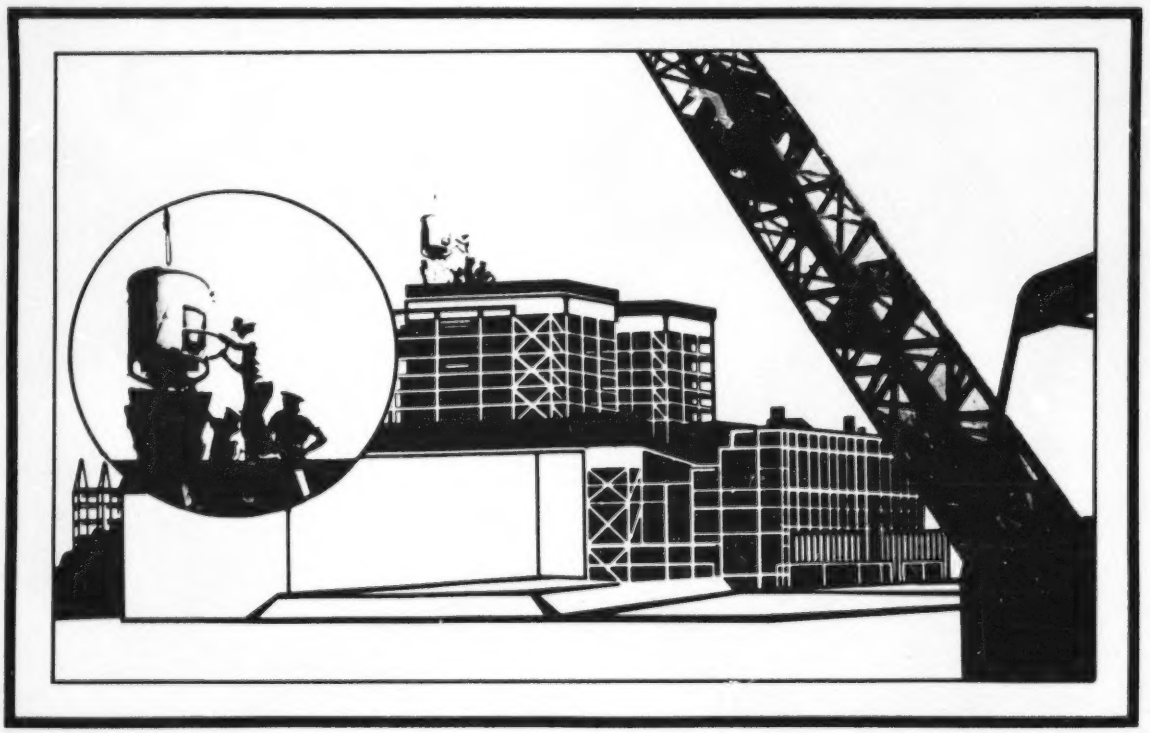
NUCLEAR TECHNOLOGY

COURSE 29 CIVIL/STRUCTURAL INSPECTION

MODULE 29-1 Inspection of Construction Operations



CE 024 271

GENERAL PHYSICS CORPORATION
Columbia , Maryland

COURSE MODULES

COURSE 29 CIVIL/STRUCTURAL INSPECTION

Module 29-1	Inspection of Construction Operations
Module 29-2	Structural Steel Materials, Installation, and Inspection
Module 29-3	Concrete Materials
Module 29-4	Concrete Preparation, Production, Placement and Finishing
Module 29-5	Concrete Testing and Inspection
Module 29-6	Prestressed Concrete Materials, Fabrication, and Inspection

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This module was prepared for General Physics Corporation by Richard Groseclose, General Physics Corporation.

GENERAL PHYSICS CORPORATION

1979

INTRODUCTION

The construction of a nuclear power plant is typically a project of 8-10 years duration, involving a full range of engineering and construction activities.

Field work begins with site work, and proceeds with excavation, dewatering, concrete work, and fill.

This module describes these activities, the equipment and materials used, and some of the inspection operations which may be performed by the QA/QC technician.

Structural steel erection work usually follows these activities, and is presented in the next Module, 29-2.

MODULE PREREQUISITES

None.

OBJECTIVES

Upon completion of this module, the student/trainee should be able to:

1. Given a description of a hypothetical nuclear power plant site, and a list of site preparation and early construction activities, organize the activities in the proper chronological order.
2. Given a typical concrete design mix and general concrete batcher tolerance limits, calculate allowable variations in batching water, cement and aggregates.

3. Given sketches of typical concrete form set-ups, label correctly the indicated component parts. To further demonstrate a knowledge of form work, answer written questions on: (1) slip forms, (2) column forms, (3) panel forms, and (4) form erection.
4. Demonstrate a knowledge of reinforcing steel installation practices by answering written questions on: (1) coverage, (2) reinforcement theory, (3) re-bar supports, and (4) re-bar location and tying practices.
5. Demonstrate a knowledge of concrete production, placement and curing operations by:
   a. calculating batching time and component material usage for a given batch plant operation and a given design mix.
   b. listing factors that should be observed during placement operations which affect concrete strength, and
   c. describing the concrete curing process.
6. Demonstrate a knowledge of form removal and surface finishing practices by answering written questions on: (1) time of removal, (2) surface repairs, and (3) characteristics of surface defects.
7. Demonstrate a knowledge of structural fill and soils testing practices by answering written questions on: (1) classes of soils, (2) soil density, (3) fill material characteristics, (4) placing and compacting procedures, (5) moisture content testing, and (6) % density tests: rubber ballon test, and sand cone test.

SITE PREPARATIONS AND EXCAVATION

Before any construction operations begin, field sites are surveyed to accurately locate boundaries and topographic features. The area to be cleared is then identified and marked, usually with stakes, in agreement with the plans and specifications. The inspector, or QA/QC technician, may be required to verify that the clearing limits have been established correctly.

A safety program must be established as mobilization begins. Any potential hazards must be identified, and arrangements made for fire protection, first aid, ambulance service, and hospitalization.

The removal of trees, bushes and other foliage is known as clearing and grubbing. In wooded areas, the first stage of clearing is swamping, which includes the initial removal of underbrush and small undergrowth which could interfere with felling of larger timber. Grubbing is the removal of stumps and roots. Timber is usually cut up with chain saws and hauled from the site, and the remaining organic materials bulldozed into piles for disposal by burning. Disposal operations must follow appropriate air pollution regulations, however. Burning permits must be obtained, and burning should not be permitted in periods of high wind. Debris must be prevented from being carried into waterways, streams or reservoirs. Clearing activities should be monitored by an inspector to assure compliance with the site plans, and applicable codes and regulations.

Following site clearing operations, access roads to the site and parking lots for construction personnel are laid out and constructed. It is not uncommon to have up to 3,000 workers on a single-unit power plant site at peak times of the construction work.

Buildings, either permanent or temporary, are then constructed for offices; personnel change facilities; shops for various crafts, such as carpenters, fitters, electricians and welders; warehouses; and sanitary facilities. Utilities are brought in and connected, and general mobilization begins.

Inasmuch as many of the heavy equipment items such as transformers, heat exchangers, and large pumps and motors are normally shipped by rail, railroad siding or spur facilities are usually constructed on plant sites. In remote areas, cement and concrete aggregate materials may also be shipped in by rail, and the rail facilities would thus be needed in the early phases of the site work.

Excavation and grading work begins when the site clearing is completed. The first stage of this work is the stripping of top soil. Top soil is usually stockpiled for later use in final grading in areas that will be seeded and landscaped.

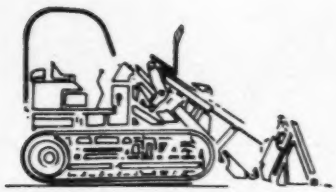
Excavation is performed with a variety of heavy equipment, including bulldozers, front-end loaders, excavators, earth movers and dump trucks. Rock formations that must be removed are drilled, loaded with explosives such as TNT and blasted. The broken material is then shoveled easily and hauled from the excavated area. Figures 29-1-1 through 29-1-3 illustrate some of the types of equipment used for excavation.

QA/QC technicians are frequently used to monitor or inspect excavation work for conformance to such drawing requirements as location, elevation, slope, and the removal of loose materials.

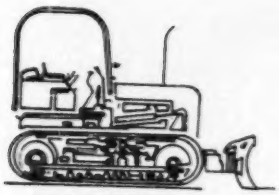
4-Wheel Drive Loader

Crawler Loader

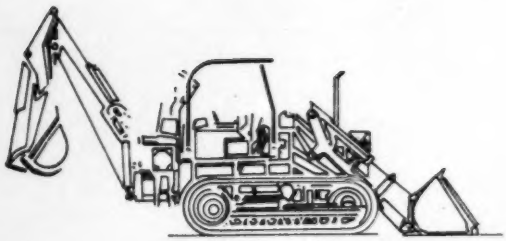
Figure 29-1-1 Construction Equipment



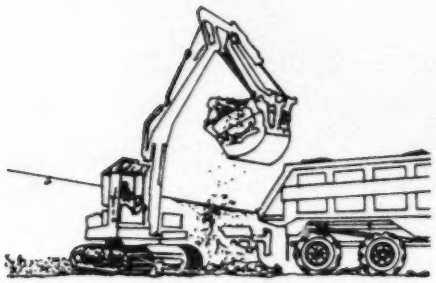
Loader



Bulldozer



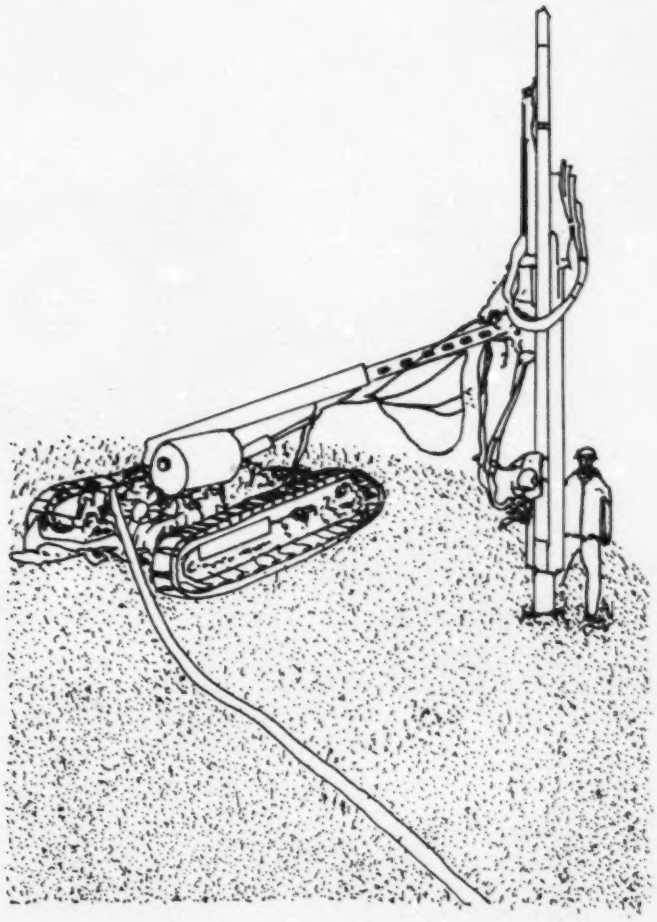
Backhoe/Loader



Excavator

Types of Crawlers

Figure 29-1-2 Construction Equipment



Pneumatic Crawler Drill

Figure 29-1-3 Construction Equipment

SITE DE-WATERING AND DRAINAGE

During excavation and other construction operations, including concrete placement and backfilling, the work site must be kept dry. On most large construction projects, the excavation site is rather deep and below the groundwater line. Special dewatering equipment and procedures are needed to maintain the area in the required condition.

One dewatering method is a combined pumping and piping system. The piping is made up of pumping points driven several feet below the dry level required, and then connecting the pumping points with headers connected to heavy duty pumps.

Another method of dewatering is direct pumping from sumps which are either open, or are made from pipe or gravel pockets.

Figure 29-1-4 shows a dewatering pumping ring system installed around a deep excavation.

The duties of site QA/QC technicians may include monitoring the effectiveness of the dewatering systems.

CONCRETE MATERIALS AND BATCHING EQUIPMENT

Concrete is a mixture of cement, aggregates, water and additives (called admixtures) which is plastic and workable when mixed, and which "sets" or hardens a few hours after mixing. Concrete is basic building material for nearly all construction projects, and is used for foundations, walls, floor slabs, roof slabs, columns, beams and storage vessels or containments.

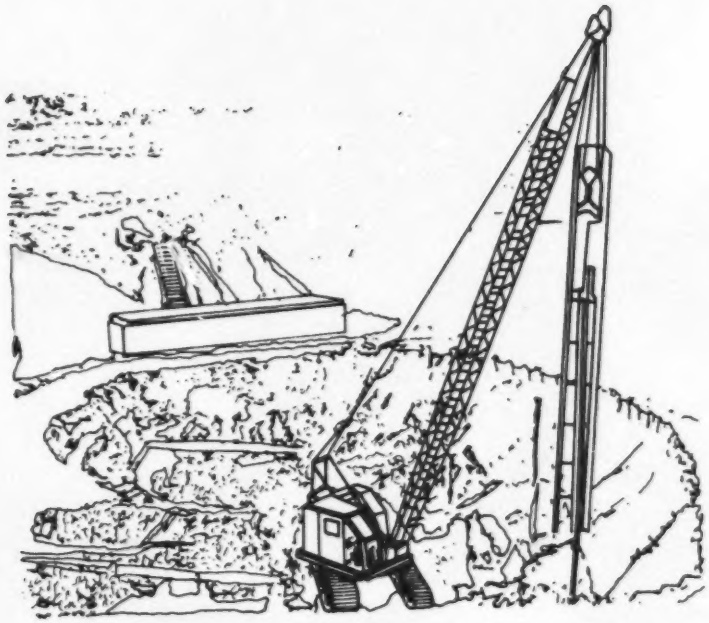


Figure 29-1-4 Dewatering Pumping Ring System

Concrete is strong in compression and relatively weak in tension, and derives its strength from the cement which binds the aggregate particles together. The strength of the hardened concrete is affected by the quality and proportions of all the component materials. Of critical importance is the amount of water used, which is expressed as the water-cement ratio.

Detailed information on the component materials is presented in Module 29-3, Concrete Materials.

To maintain the product of consistent, high quality concrete with minimal variations between batches, the materials must be measured accurately and mixed properly.

Concrete may be mixed in two principal ways for construction use - central mixed or truck mixed (also called transit mixed). In the first, the concrete is mixed in a stationary mixer at the batch plant and delivered to the work site in a truck mixer or agitator or other transportation device. In the second, the concrete is mixed in a truck mixer - generally in transit to the job but frequently after the job is reached. Each of the types of mixing operations has its own special problems of control. The facilities for the control of the quality of the ingredients and of the accuracy of the measuring of the dry materials are the same for the central mixing and truck mixing operations. The central mixing plant provides for better control of mixing water and consistency than does the truck mixing operation, a critical factor in the resultant concrete quality. The truck mixing operation, however, provides the opportunity to better control the time between the introduction of mixing water and the discharge of the concrete at the job location.

Concrete component materials are loaded and weighed in suitable containers called batchers. (Thus the expression,

"batch plants".) Cement materials are not loaded and weighed in the same batcher used for aggregate materials. Each batcher is normally equipped with a scale and also with the necessary mechanisms for its operation. The charging device for each batcher must be capable of stopping the flow of materials within specified tolerances. Typical batcher tolerances are as follows:

- Cement Batcher - ±1% of the required weight of material being weighed, or ± 0.3% of scale capacity, whichever is greater.
- Aggregates 1½" or smaller - ±2% of the required weight of material being weighed, or ± 0.3% of scale capacity, whichever is greater.
- Aggregates larger than 1½" - ±3% of the required weight of material being weighed, or ± 0.3% of scale capacity, whichever is greater.
- Water - ±1% of the required weight of material being weighed, or ± 0.3% of scale capacity, whichever is greater.
- Admixtures - ±3% of the required weight of material being weighed, or ±0.3% of scale capacity, or ± the minimum dosage rate for one sack of cement, whichever is greater.

Batchers range from manual through all stages to complete automation. All are capable of providing satisfactory accuracy.

A manual batcher is equipped with gates or valves which are opened and closed manually, with the accuracy of the weighing operation being dependent upon the operator's visual observation of the scale. The gates or valves may be operated by hand, or by pneumatic, hydraulic, or electrical power assists. A semi-automatic batcher is one equipped with gates or valves which are separately opened manually

to allow the material to be weighed, but which are closed automatically when the designated weight of each material has been reached.

An automatic batcher is one equipped with gates or valves which, when actuated by a single starter switch, will open automatically at the start of the weighing operation of each material, and close automatically when the designated weight of each material has been reached.

Batching equipment is usually arranged to permit "ribbon" loading - that is, the simultaneous loading of the cement and aggregates. In central-mixing operations, the water is also added with the other materials, but in truck-mixing operations, the water is added later.

Detailed information on concrete batching and mixing is presented in Module 29-4, Concrete Preparation, Production, Placement and Finishing.

The QA/QC technician, in the capacity of an inspector, may be required to inspect all phases of the concrete batching operations, including witnessing the calibration of cement scales, aggregate scales, water meters and admixture meters.

CONCRETE FORMS

"Form work" is the term employed to include the total system of support for freshly placed concrete - form sheathing plus all supporting members, hardware, and bracing.

The quality of cast-in-place concrete, relative to size, shape and alignment of slabs, beams, walls and other concrete structural elements, depends on accurate construction and setting of the forms.

Forms must be:

- built to correct dimensions.
- sufficiently rigid under the construction loads to maintain the desired shape.
- stable and strong enough to maintain alignment.
- substantially constructed to withstand handling and reuse without losing dimensional integrity.
- economical to construct and use.

Forms are most commonly constructed of wood. Wood is easily worked and has the unique characteristic of the capacity to absorb large overloads for short periods.

Figure 29-1-5 illustrates typical building construction using reinforced concrete for footings, walls, columns, and slabs.

The principal construction requirements for footings are sound concrete and correct position to align with walls and columns. Appearance of footings is usually unimportant because they are below grade. Sometimes fabricated forms are omitted completely and the concrete is cast directly against the excavation. Since footings are generally shallow, lateral pressure from the fresh concrete is relatively small and the required bracing is simple. Figure 29-1-6 shows a typical form arrangement for a wall footing.

The forms for simple, rectangular column footings are bottomless boxes. They are constructed with two end sections and two sides and equipped with ties to prevent the sides of the box from bulging under concrete pressure. A template for positioning dowels may be attached to the top of the form box. Two types of column footing forms are shown in Figure 29-1-7, one with external ties and the other with internal ties.

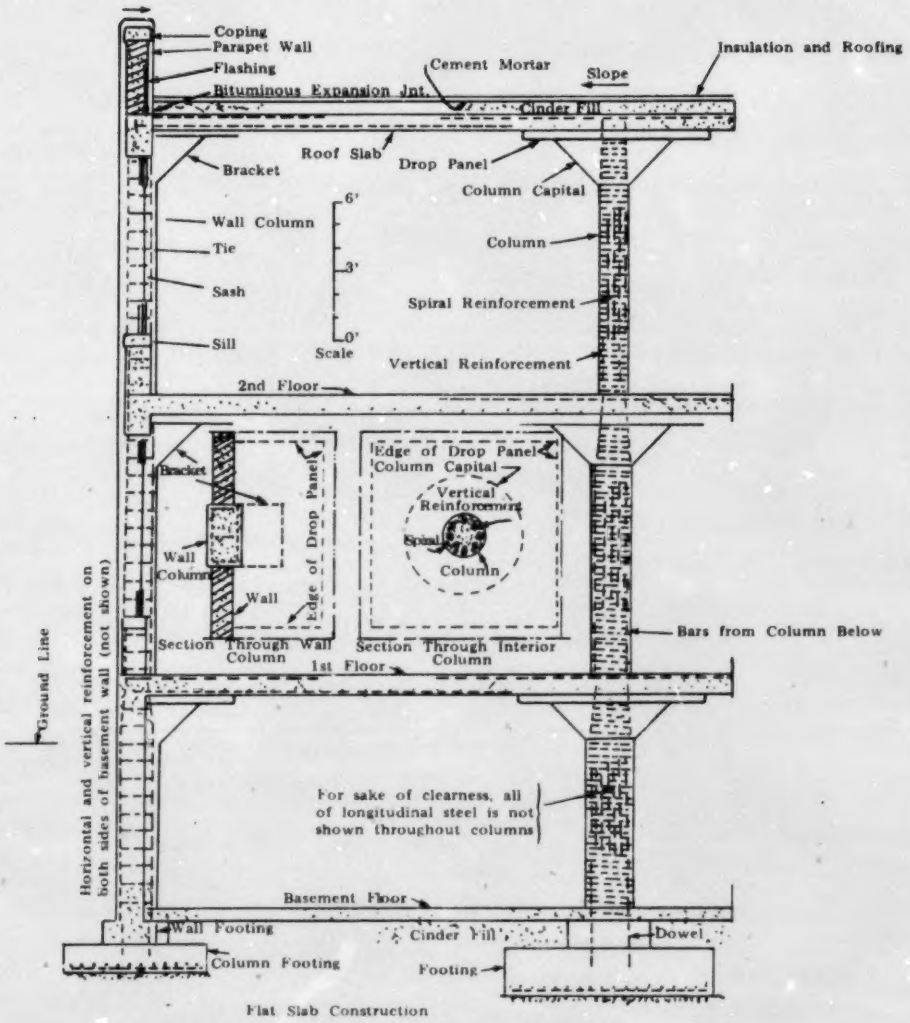


Figure 29-1-5 Typical Reinforced Concrete Building Construction

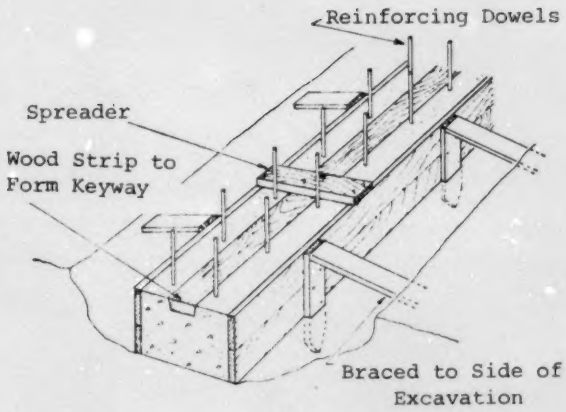


Figure 29-1-6 Typical Wall Footing Form

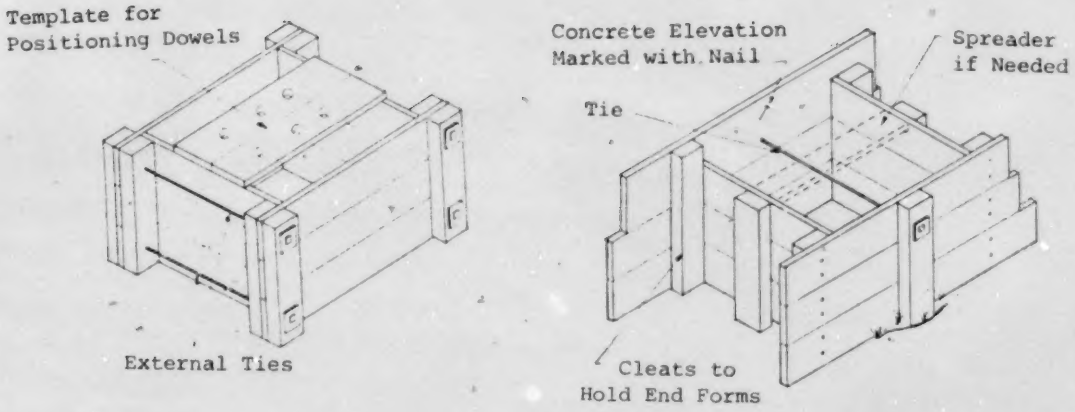


Figure 29-1-7 Typical Column Footing Forms

The first step in constructing a wall form is to attach a sill or plate to the footing as a base for studs. Special care must be taken to align this strip, as it will determine the line of the wall. Studs are then erected, attached to the sill and held vertical by temporary braces. Sheathing material, of either boards or plywood panels, is then attached to the studs with nails. When the first wall form face is completed, the second is fabricated and set in place. Holes are drilled through both faces at the proper locations, and the wales are installed with ties. Permanent bracing is installed after the wales are in place or as the form is plumbed. Figure 29-1-8 shows the components of a typical wall form, set on a cast footing.

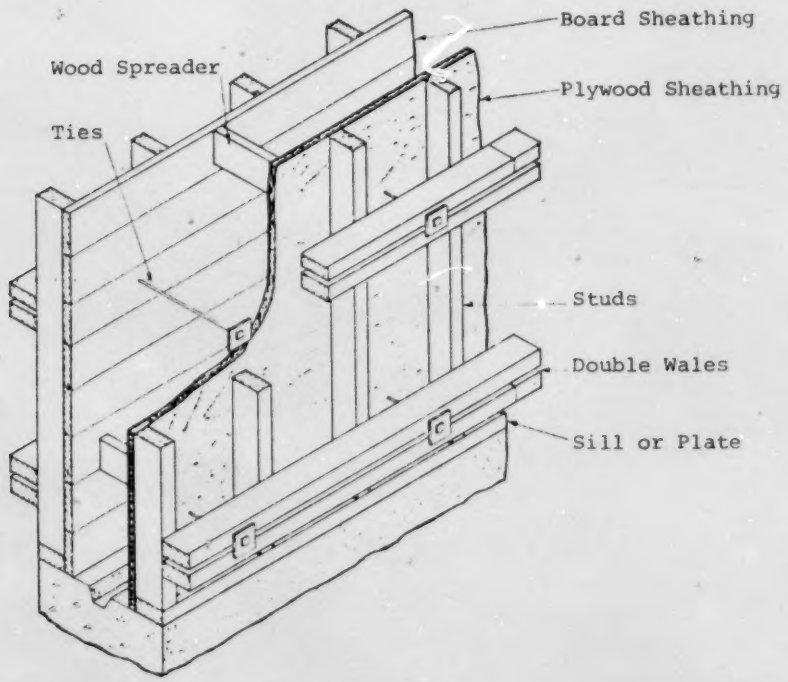


Figure 29-1-8 Typical Wall Form Components

Concrete form ties are tensile units designed to hold concrete forms secure against the lateral pressure of unhardened concrete. The two basic types of ties used are the continuous single member and the internal disconnecting types.

The continuous single member tie grips the exterior of the form, and is usually one of the types shown in Figure 29-1-9.

Snap Tie with Small Cone Spreader

Washer Spreader, Crimped for Break Back

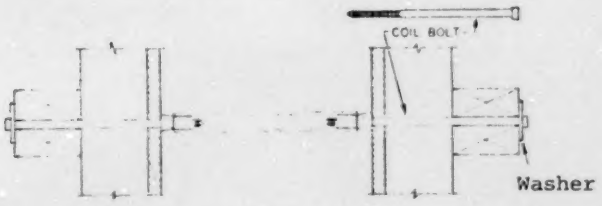
Wood Cone Spreader

No Spreader; May be Pulled or May be Equipped with Break Points

Taper Tie to be Withdrawn

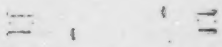
Figure 29-1-9 Continuous Single Member Ties

The internal disconnecting tie has an inner part with threaded connections to removable external members. The internal member usually remains in the concrete. Examples of these ties are shown in Figure 29-1-10.

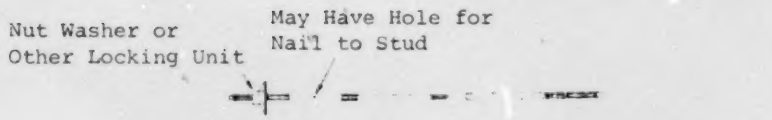


Coil Type Tie With Cone Spreader

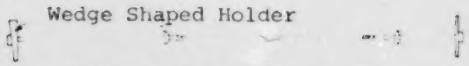
Plain Coil Type
(Also Available with 4 Struts)



Water Seal Coil Type



Plain Tie With She-Bolt Disconnecting Ends



Crimped Tie With Disconnecting Ends

Figure 29-1-10 Internal Disconnecting Ties

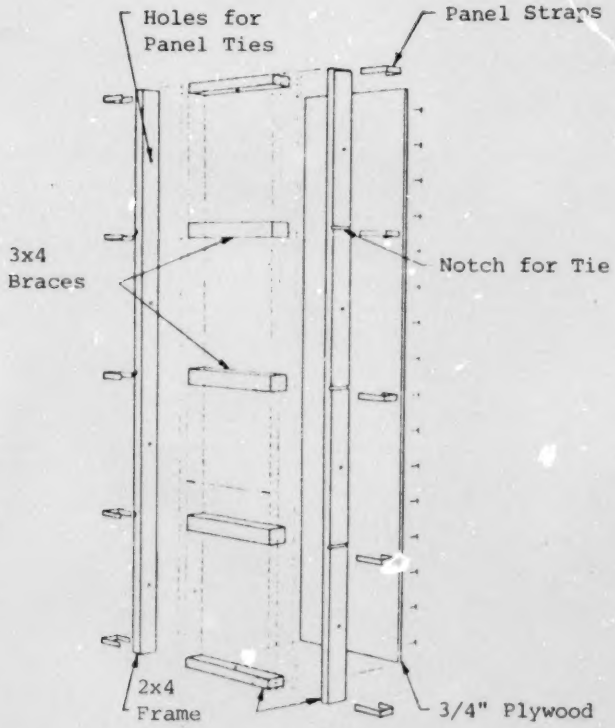


Figure 29-1-11 Pre-Fabricated Panel Form

Many contractor-built or ready-made prefabricated panel forms are also used for large project wall construction. Preassembled panels are set into position, tied together, and supported and braced as other types of wall forms. Figure 29-1-11 shows a typical contractor-built panel form. Figure 29-1-12 shows typical ties which are used on the prefabricated panels.

Strap Tie

Loop End Tie

Figure 29-1-12 Typical Panel Form Ties

Column forms require tight joints and extra care in anchoring the bases in position, due to the high lateral pressures imposed by the concrete during placement operations. Column bases may be formed as shown in Figure 29-1-13. Column forms may be constructed as shown in Figure 29-1-14 or Figure 29-1-15. Tall columns frequently have windows or openings at midheight or other intervals to make placing and consolidating the concrete easier. Clean-out openings as shown in Figure 29-1-15 are usually constructed at the column base for removal of waste or debris before concreting begins.

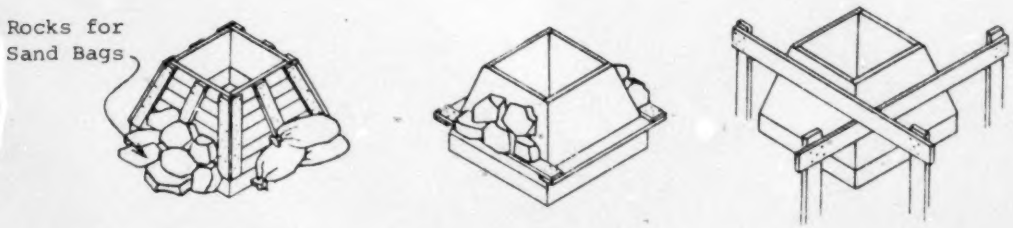


Figure 29-1-13 Column Base Forms

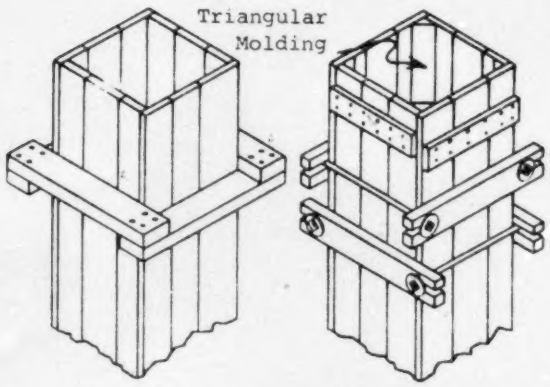


Figure 29-1-14 Column Forms

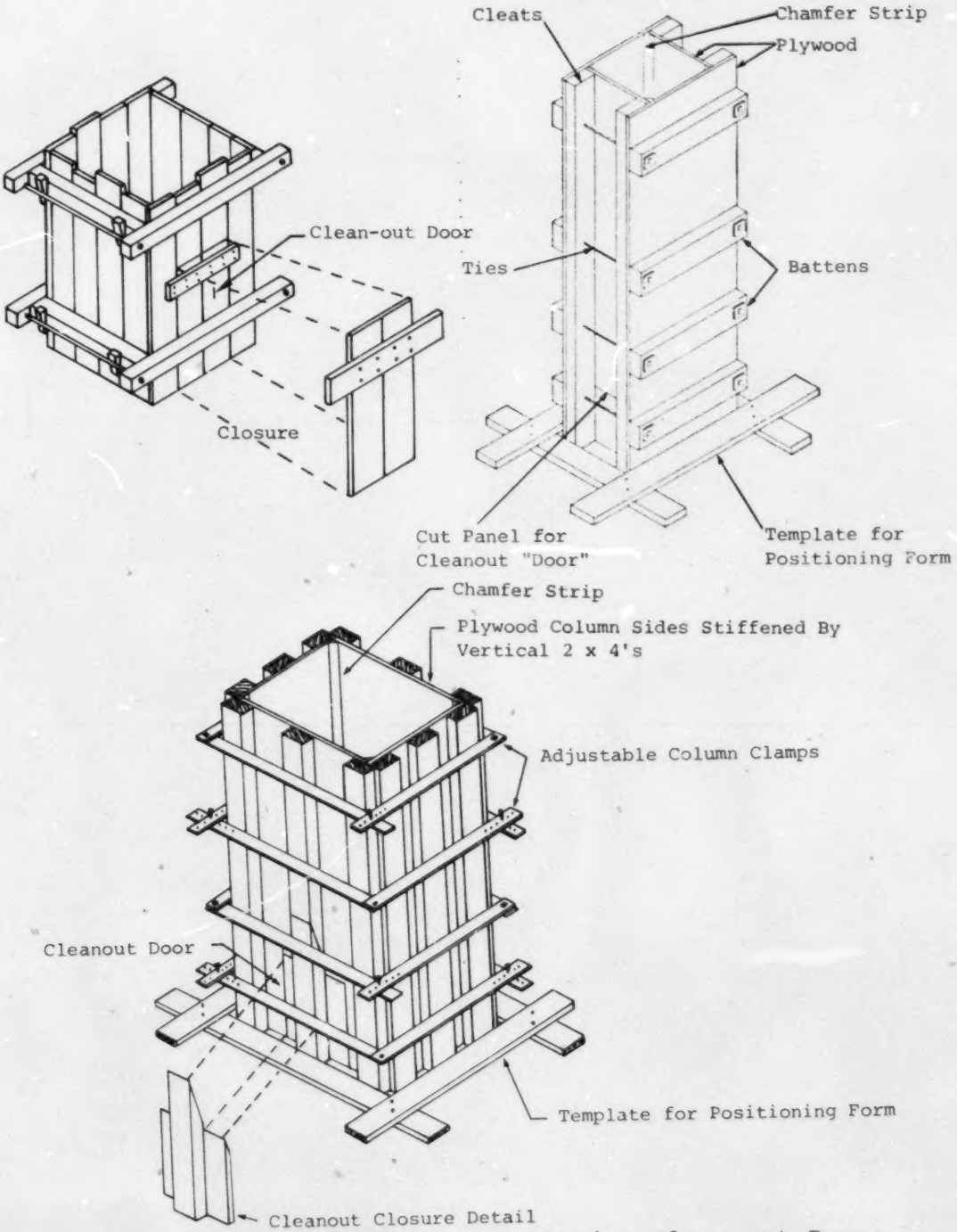


Figure 29-1-15 Column Forms Showing Clean-out Doors

Beam and grinder form work consists of a beam bottom and two ties, plus the necessary ties, shoring and braces. Section views of typical beam forms are shown in Figure 29-1-16.

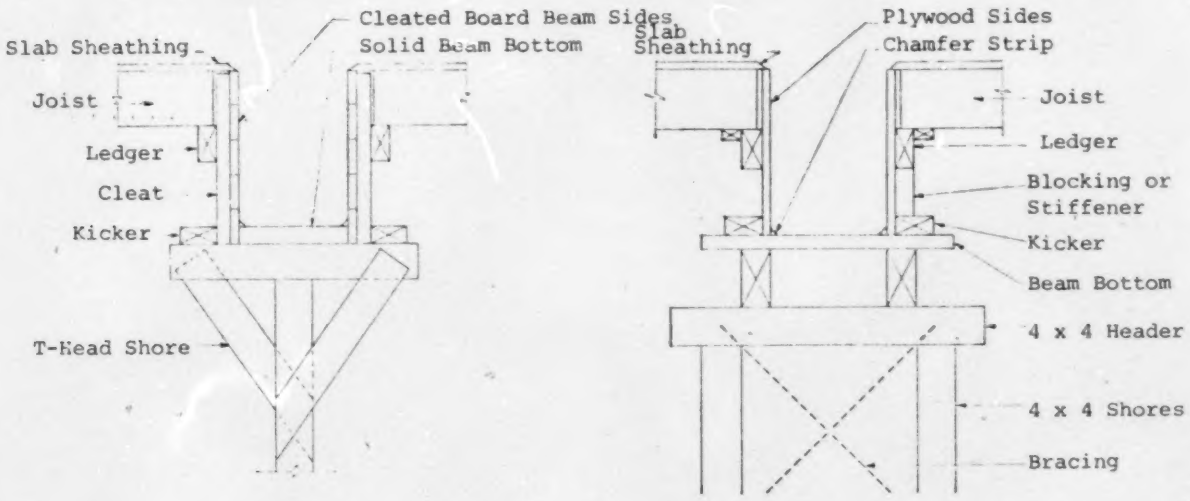


Figure 29-1-16 Typical Beam Forms

Slab forms consist simply of sheathing panels supported by joists and braces, as shown in Figure 29-1-17. They may be supported by beams, such as those cast in the forms shown in Figure 29-1-16. Slabs may be cast monolithically (in a single mass) with a beam, as shown in Figure 29-1-18.

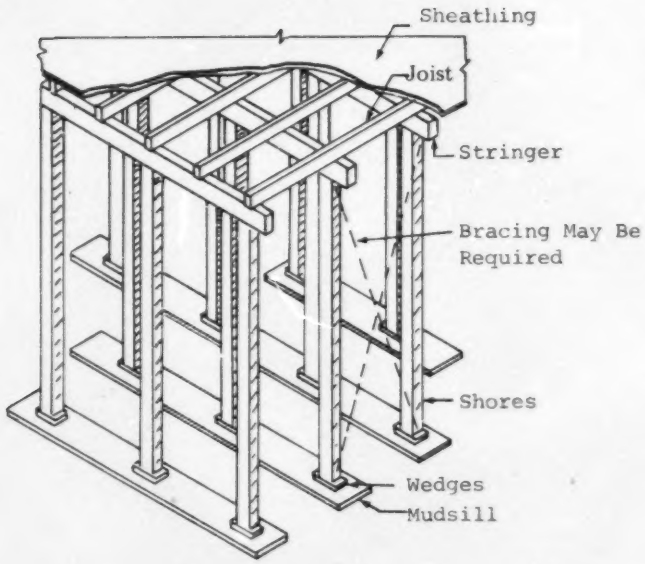


Figure 29-1-17 Flat Slab Form

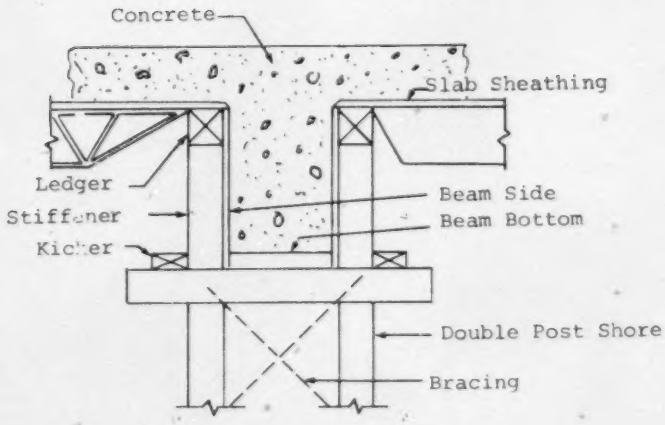


Figure 29-1-18 Slab and Beam Construction, Monolithic Pour

Curved forms are also used frequently on power plant projects. Large radius curves can easily be formed with standard prefabricated panels, or with plywood sheathing wrapped around blocking frames. Short radius curves are usually made with multi-layers of thin plywood supported on curved blocking members, as shown in Figure 19.

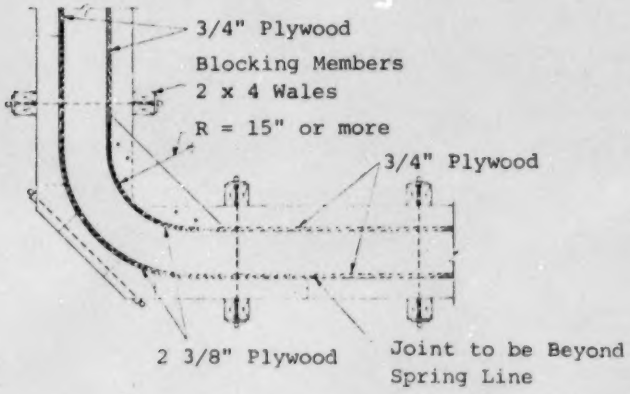


Figure 29-1-19 Small Radius Curved Form

A special type of form sometimes used is the slip form. This form is used on vertical structures such as chimneys, elevator shafts, and core structures for buildings. The form is jacked vertically on reinforced jacking bars or dowels embedded in the formed concrete. The rate of vertical rise of the forms and the concrete is timed to a balance between curing of the concrete, and development of sufficient strength to hold the forms, while not being so slow as to preclude proper bonding of the new concrete as it is placed on top of the prior material.

The quality of the finished concrete depends on good workmanship in constructing and setting the forms, including attention to the following points:

- proper splices of studs, wales or shores
- staggering of joints or splices in sheathing, plywood panels, and bracing.
- proper seating of shores.
- proper number and location of form ties or clamps.
- proper tightening of form ties or clamps.
- secure connection of shores to joints, stringers or wales to resist uplift or torsion at joints.
- proper coating of forms.

All of these points should be checked by the cognizant inspector or field supervisor before concrete is placed, or admitted to the forms. These duties may be assigned to a qualified QA/QC technician.

Supplemental information on the selection and usage of concrete forms is available from the American Concrete Institute (ACI).

INSTALLATION OF REINFORCING STEEL AND OTHER EMBEDMENTS

The term reinforcing steel is applied to the steel, usually deformed bars, which is used to reinforce concrete where forces exist (tension) which the concrete cannot withstand.

Tension in concrete can be caused by bending or shear as in beams, by drying shrinkage after concrete hardens, and by temperature changes. Figure 29-1-20 illustrates how a loaded member deflects and produces tension on the lower surface, sometimes producing tension cracks. Concrete is weak and brittle in tension, and without reinforcement,

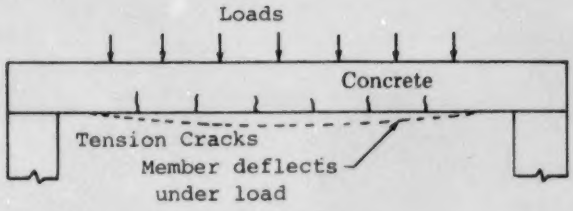


Figure 29-1-20 Deflection and Tension in Loaded Member

would fail suddenly without warning shortly after the first crack appeared.

Reinforcing steel, then, is required in that part or area of a concrete structure which is in tension. Figure 29-1-21 shows five types of members and how reinforcing bars, or "re-bars", are located within, along with exaggerated illustrations of the shape each assumes under load.

It is important that bars be placed and held in position as shown on the placement drawings. The strength of any concrete member is greatly affected by improper positioning of the re-bars. For example, lowering the top bars or raising the bottom bars by ½" more than specified in a 6" thick slab could reduce its load carrying capacity by 20%.

Standard practice allows a tolerance of $\pm$½" in the positioning of bars above forms in the bottom of beams, joints and slabs.

The proper embedment of bars in concrete is also important. The concrete cover protects the bars from fire hazards, corrosion and weather exposure. Unless otherwise specified, the minimum standard covers (outside of bar to face of concrete) illustrated in Figure 29-1-22 should be observed.

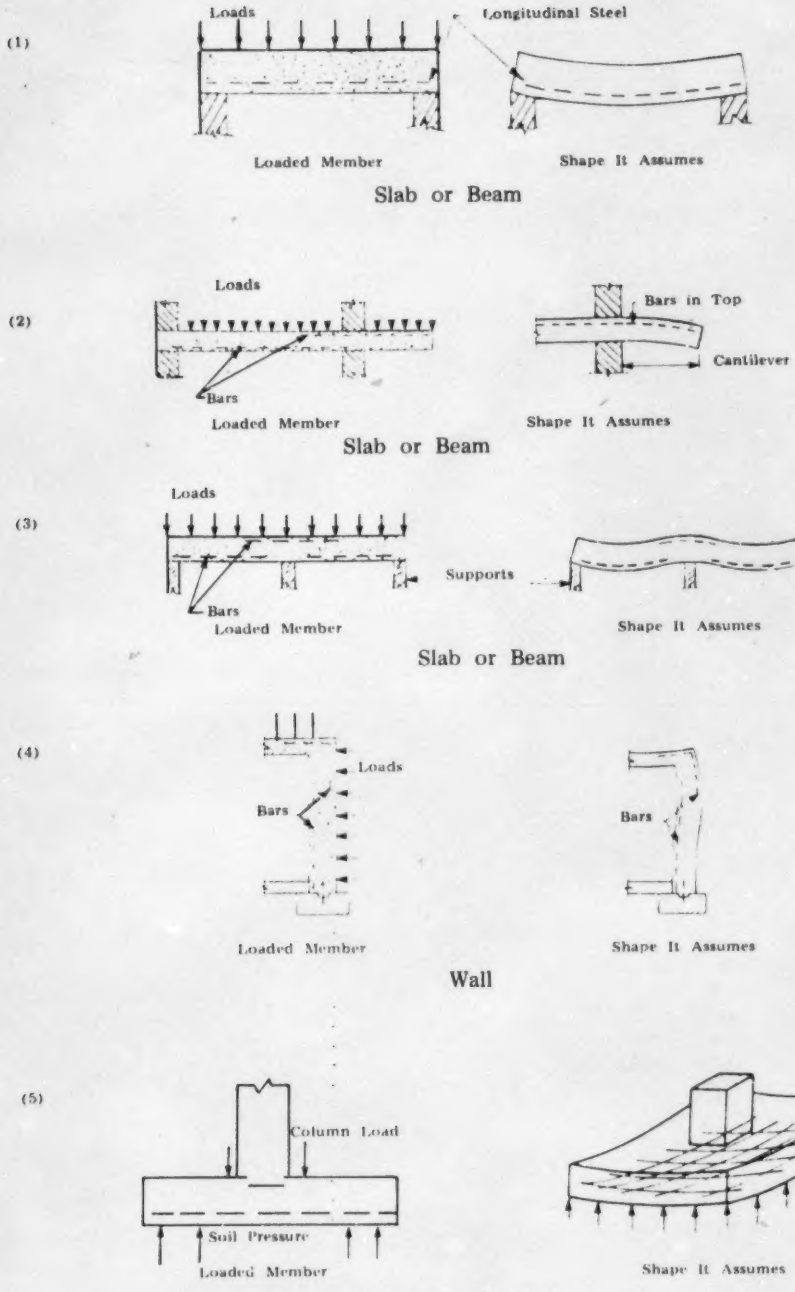


Figure 29-1-21 Structural Concrete Shapes: Forces and Deflection

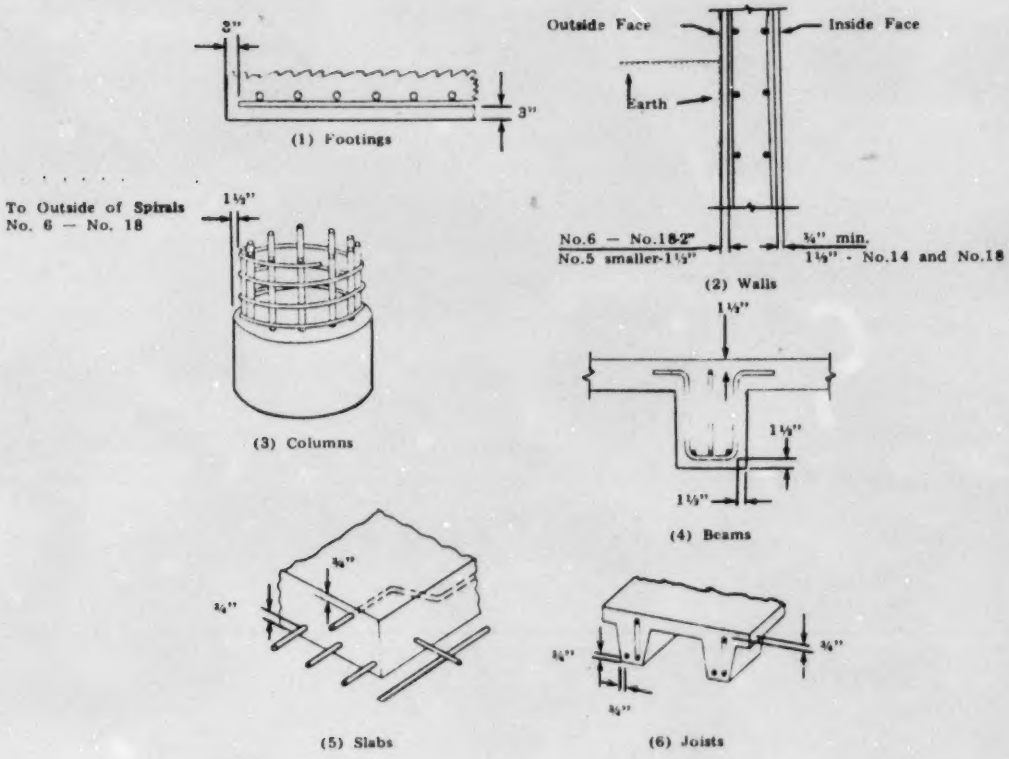


Figure 29-1-22 Minimum Concrete Cover Over Reinforcing Steel

Bar supports are used to firmly hold bars at the required clearance from the forms before and during the placing of concrete. Bar supports may be formed from steel wire or rods, or concrete blocks. Standard types are sizes of wire supports are listed in Figure 29-1-23.

Pre-cast concrete blocks are available in three types and various sizes, as shown in Figure 29-1-24.

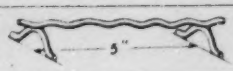
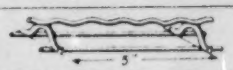
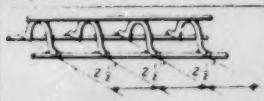
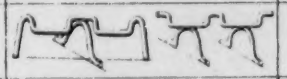
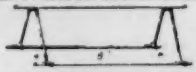
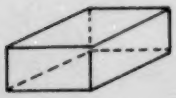
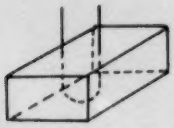
Symbol	Bar Support Illustration	Type of Support	Standard Sizes
SB		Slab Bolster	¾, 1, 1½, and 2 inch heights in 5 ft. and 10 ft. lengths
SBR		Slab Bolster with Runners	Same as SB
BB		Beam Bolster	1", 1½", 2"; over 2" to 5" heights in increments of ¼"; in lengths of 5 ft.
UBB		Upper Beam Bolster	Same as BB
BC		Individual Bar Chair	¾, 1, 1½, and 1¾" heights
JC		Joist Chair	4, 5, and 6 inch widths and ¾, 1, and 1½ inch heights
HC		Individual High Chair	2 to 15 inch heights in increments of ¼ in
CHC		Continuous High Chair	Same as HC in 5 and 10 foot lengths
UCHC		Upper Continuous High Chair	Same as CHC

Figure 29-1-23 Standard Types and Sizes of Wire Bar Supports



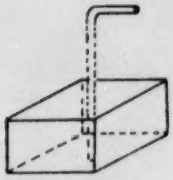
Size Range: 2" x 2" x ¾" thick, through 6" x 6" x 3" thick.

(1) Plain Precast Concrete Blocks



Size Range: 2" x 2" x ¾" thick, through 3" x 3" x 3" thick.

(2) Precast Concrete Blocks With Tie-Wires



Size as shown.

(3) Precast Concrete Doweled Blocks

Figure 29-1-24 Precast Concrete Block Bar Supports

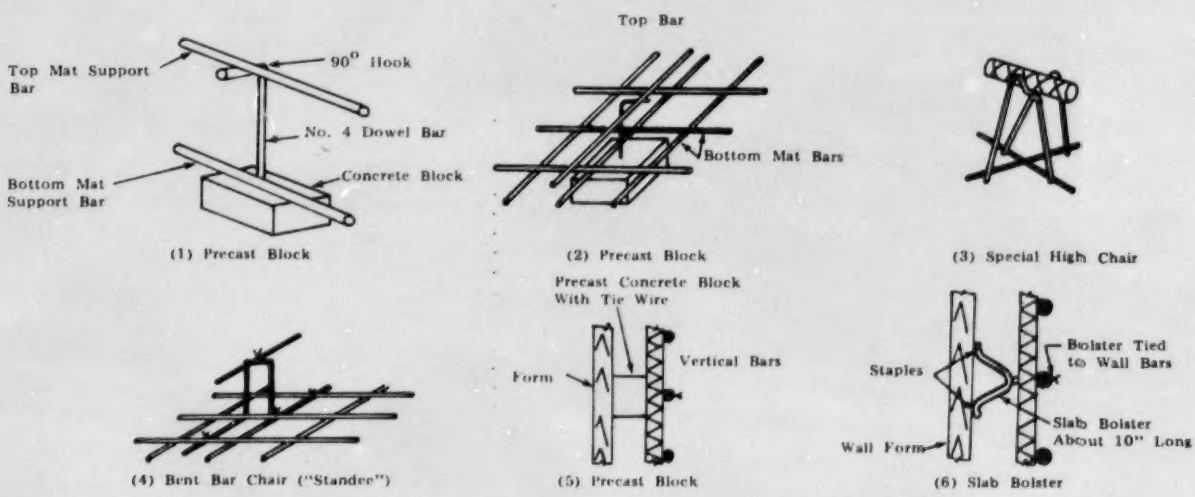
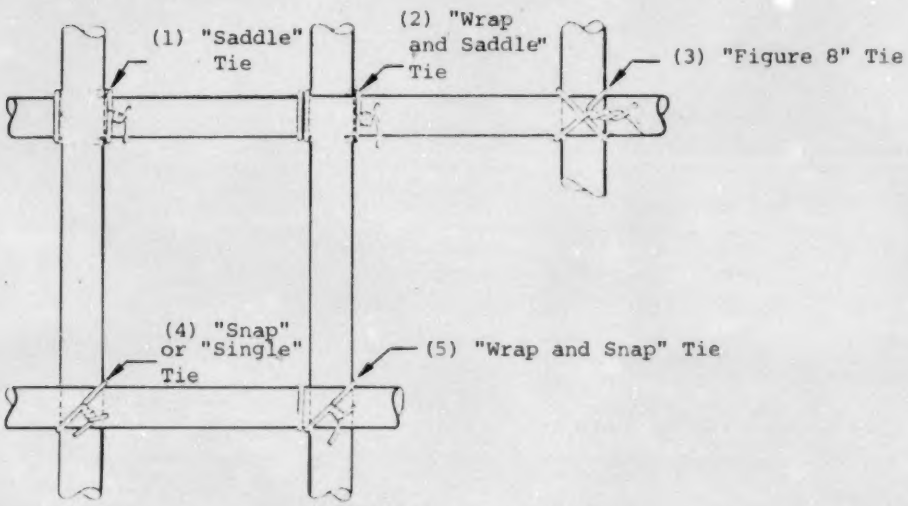


Figure 29-1-25 Use of Bar Supports

The tying of bars is essential to maintain their position during concrete placing and work done by other trades. The tying of bars does not add to the strength of the structure, but the correct position of each bar does. It is usually adequate to tie every 4th or 5th intersection.

The wire usually used for tying reinforcing bars is #16 gauge black soft annealed wire, carried in coils on holders or reels. Various types of ties are used, but the more common ones are illustrated in Figure 29-1-26.



(1) Used for securing column ties to vertical bars, or securing footing or other mats
(2) Used where a great strain is placed on ties
(3) Used occasionally in walls
(4) Most commonly used for flat, horizontal work
(5) Most commonly used for wall reinforcement work

Figure 29-1-26 Wire Ties

Two examples of re-bar installation are shown in Figure 29-1-27.

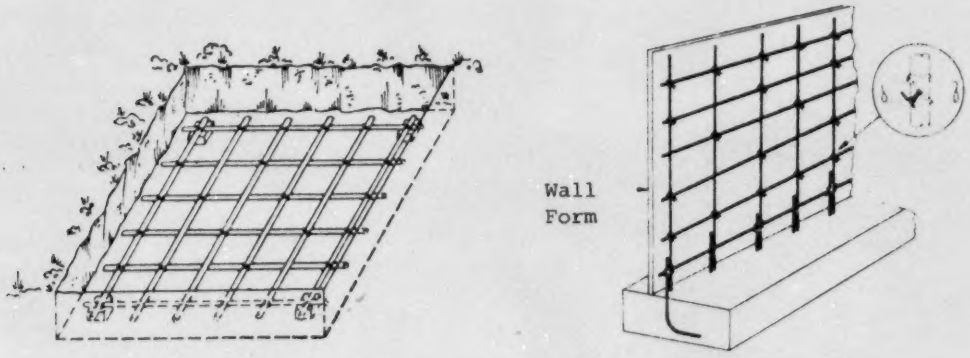


Figure 29-1-27 Re-Bar Installation

Re-bar splices are frequently made by lapping (wiring or tying), welding or with mechanical couplings. Users are cautioned, however, that when spot or tack welding is performed on re-bar, localized heating and arcing may cause a "notching effect" and reduce the strength of the affected material as much as 30-35%. On nuclear projects, usually the only welding permitted on re-bar is for splicing work using the "Thermit" process where the bar ends are placed in a mold or sleeve with a small gap between. The new material (molten steel) flows into the mold and fuses to and around each end of the bar. This process produces a spliced area stronger than the bar itself.

Inspection of reinforcing steel is one of the most important steps in obtaining a satisfactory and acceptable job. The person performing the inspection must be knowledgeable in, and prepared to interpret and explain the applicable plans and specifications.

Before re-bar is placed, the following items should be checked by the inspector:

1. Only approved, latest revision drawings being used.
2. Reinforcing bars are of correct grade and size.
3. Bar supports are correct types, as specified.
4. All required test reports have been received, and are acceptable.

During the placing of bars, the following items should be checked:

1. Number of pieces, size, length, shape and grade of all bars in each structural member.
2. Concrete cover between forms and steel bars.
3. Type, finish, height and location of bar supports.
4. Proper positioning and tying of bars.
5. All splices for acceptability.

Additional information about reinforcing steel usage is available from the Concrete Reinforcing Steel Institute (CRSI).

Embedments are parts such as structural anchors, drain piping, and sleeves which are set in place permanently, surrounded by concrete. Such items are located, set in place and secured within the form before the concrete is placed. They may be wired to re-bar, attached to steel chairs or other support steel, or blocked with pre-cast concrete block spacers. Embedments must be located and arranged accurately as they usually attach or align with other equipment, piping or a structure later in the construction sequence. Embedments should be checked for location and alignment by the inspector along with the re-bar pre-placement inspection.

All inspection operations described in this section may be assigned to a qualified QA/QC technician.

CONCRETE PRODUCTION, PLACEMENT AND CURING

The selection of concrete proportions involves a balance between reasonable economy, and requirements for strength, placeability, durability, and sometimes, appearance. For projects such as nuclear power plants, all concrete is produced to precise specifications which have been proven by mixing and physically testing concrete samples comprised of the representative materials. The various formulations of mixes are called "design mixes".

A typical design mix for foundation mat concrete having an average 28 days compressive strength of 3500 psi, may require the following batch weights per cubic yard of concrete:

water (mixing):	343 lb.
cement:	553 lb.
coarse aggregate (dry):	1896 lb.
fine aggregate (dry):	1203 lb.

When concrete is batched then to this design mix, these proportions of materials will be used. For example, to "batch" a 9 cubic yard load in a transit mix truck, the following quantities would be used:

water: 9 x 343 lb.	= 3,087 lb.
cement: 9 x 553 lb.	= 4,977
coarse aggregate: 9 x 1896 lb.	= 17,064
fine aggregate: 9 x 1203 lb.	= 10,827
Total Weight	35,955

Concrete batch plants are sized to produce concrete at a certain nominal rate, i.e. cubic yards per hour. A typical batch plant on a nuclear construction project may be rated

at 250 cubic yards per hour. This rating is the approximate maximum rate at which it is capable of batching concrete. This rating is then used to calculate the rate of component materials usage, and the time required to produce the concrete for large pours. For example, the placement of a large foundation mat requiring 1500 cubic yards of concrete is being planned for a monolithic pour (poured continuously in a single unit).

1. What is the minimum time required to batch the required concrete? Divide the amount of concrete required by the production rate of the plant: 1500 cubic yards ÷ 250 cubic yards/hour = 6 hours required.
2. Using the proportions listed for the 3500 psi concrete design mix, how much cement and aggregates will be required in tons? Design mix, quantities per cubic yard:

Cement:	553 lb.
Coarse aggregate:	1,896 lb.
Fine aggregate:	1,203 lb.

Materials required for pour:

Cement: (553 lb./yd. x 1500 cu. yds.) ÷ 2,000 lb./ton = 414.75 tons

Coarse aggregate: (1896 lb./yd. x 1500 cu. yds.) ÷ 2,000 lb./ton = 1,422 tons

Fine aggregate: (1203 lb./yd. x 1500 cu. yds.) ÷ 2,000 lb./ton = 902.25 tons

Before the concrete batching and placement operation is started, it must be verified that sufficient quantities of materials are on hand, and all necessary equipment is functional and in proper adjustment or calibration. A final inspection of the placement area and forms should also be made to verify proper cleanliness and freedom from obstructions.

During the concreting operation, continuous inspection should be performed. The major items that affect the ultimate concrete quality, and require attention are outlined below:

- Working conditions - Adequate lighting. Provision for covering and protection from weather.
- Batching - Proportioning of materials. Proper equipment operation. Accurate control of water addition.
- Mixing - Proper mixing time (not overmixed). Delay of batches in mixer.
- Control of consistency - Observation of concrete being placed. Adjustments in mix. Tests.
- Control of air content - Use of admixtures. Control of mixing time.
- Conveying - No segregation of materials. No excessive stiffening or drying out.
- Placing - Observe for uniform, dense concrete. Maintain continuous operation. Do not exceed maximum vertical drop. No dropping against forms or reinforcement. Disposition rejected batches.
- Consolidation (vibration) - Thorough and uniform consolidation.
- Finishing of unformed surfaces (e.g. floor slabs) - Alignment of surfaces. Proper surface layer of mortar. Final troweled surface.

Curing of the concrete starts immediately after finishing or initial set. Moisture must be retained in the concrete during the hydration of the cementitious materials (hardening) so that the desired strength and other properties of the concrete are developed. An adequate quantity of mixing water is normally in the concrete at the time of placement, but water is lost through evaporation and absorption by aggregates and forms.

The two general methods employed for curing are (1) maintaining a moist environment from the continuous or frequent application of water, and (2) the prevention of water loss by means of sealing materials.

The first method, known as water curing, may be accomplished by "ponding" (or flooding) of the surface, water fog spraying or sprinkling, or covering the surface with an absorbent material such as burlap or cotton mats and spraying occasionally with water.

Sealing materials are sheets or membranes of plastic film, waterproof paper or liquid membrane forming compounds placed on the concrete to reduce the loss of water.

Additional protection is needed for the concrete under extreme weather conditions. In cold weather, protection from freezing may be secured by insulation with layers of dry, porous material such as straw or hay or commercial insulating material. In hot weather, the need for adequate continuous curing with moisture is greatest during the first few hours after placement of the concrete, to avoid rapid drying.

FORM REMOVAL AND SURFACE FINISHING

The recommended time of removal of forms and shores is usually specified by the architect-engineer. Premature removal may cause failure of or injury to the concrete which may not have attained full strength. Supporting forms and shores must not be removed from beams, floors and walls until these structural units are strong enough to carry their own weight and any approved superimposed load. Where reuse of forms is planned, it is desirable to remove the forms and shores as early as possible.

In warm weather, early form removal permits specified curing work to begin. The exposure of "green" concrete (partially cured) also permits surface repairs or treatment to be performed more easily due to the favorable bonding surface. In cold weather, the forms provide insulating protection from the cold and should be left in place longer, thereby minimizing the effects of thermal shock and subsequent damage to the concrete.

Forms should be constructed and erected in such a way to permit easy removal or "stripping". Stripping requires considerable care on the part of workmen to avoid damage to the green concrete, which can be marred by scratching and chipping. Forms should be handled carefully to extend useful life. Form panels should not be dropped, but should be handed down or lowered on ropes, cables or other devices to avoid damage. Curing procedures should start immediately when the forms are removed.

It is usually necessary to fill or repair voids and imperfections in formed concrete surfaces. Holes are left from form-tie removal, and imperfections may result from ineffective vibration during concrete placement. The most commonly found surface defects are:

1. "honeycomb" - exposed coarse aggregate particles forming a cell-like structure. Caused by poorly mixed concrete, not adequately puddled with cement mortar.
2. entrapped air voids - surface pits or holes resulting from trapped bubbles of air.
3. "sand streaking" - fine granular or porous streak-like areas, resulting from a deficiency or washing-out of fines or cementitious materials.
4. "pour lines" - dark, stain-like lines showing on the formed surface demarking the boundary of adjacent batches or "lifts" of concrete.

Serious "honeycomb" or other extensive porous surface conditions may have to be chipped out and repaired, but it usually is acceptable to repair the area by troweling on a mortar mixture. In some cases, specifications are written which require that all exposed concrete surfaces be final finished uniformly, for appearance, by rubbing on a thin mortar mixture consisting of cement, sand and water.

Additional information on concrete placement, finishing and curing is presented in Module 29-4. Concrete inspection and testing operations, which are frequently handled by QA/QC technicians are covered in Module 29-5, Concrete Testing and Inspection.

STRUCTURAL FILL MATERIALS AND INSTALLATION

The term fill is used to designate all man-made deposits of natural soil or waste materials. The term structural fill indicates that the filled area may be required to support some type of structure, such as a floor slab or road paving. The term backfill generally refers to the fill material replaced in trench type excavations and foundation excavations along walls, to bring the ground elevation up to the original or the designated finished grade.

Natural soils, which are free from rubbish and organic materials such as limbs and roots, and which compact easily, are usually required for the structural fill materials used on projects such as nuclear plant construction.

The principal types of soils may be divided into two classes according to the sizes of the grains of which they are composed. The coarse grained soils are sands and gravels, and the fine grained soils are silts and clays. Soils may be comprised of mixtures of these materials, and may contain organic material such as peat.

Most sands and gravels are composed of grains of quartz or silicon dioxide, but may be granite, basalt or other rocks. The grain shapes may be rounded or angular, and packed tightly together in dense deposits.

Clay particles are extremely small, and are composed primarily of hydrous aluminum silicate. The particle shape is flat or flake-like and forms a deposit in the form of a network or mesh of solid grains with the intervening spaces, called voids or pores, filled with water.

Silts are usually composed of minute particles of silicon dioxide and are rounded in shape.

The specific gravity of different soil particles is quite uniform, generally falling between 2.5 and 2.8. Soil density, however, may vary from about 70 lbs /cubic feet to over 150 lbs/cubic feet, because of the differences in voids in the soil, depending on the grading of the grain sizes; the moisture content; or the extent to which it has been consolidated or compacted by rolling, tamping or vibrating.

The permeability of a soil, (i.e., its ability to permit water to pass through its pores or voids), has a marked effect on the way the soil compacts and the rate at which it compresses under structural loads. Sand offers little resistance to the passage of water because of its permeability, and the final degree of compression is reached almost as soon as the load is applied, even though the pores may be filled with water. Clay, however, is quite impermeable and the pores of natural deposits are normally filled with water so that compression takes place very slowly and continues over a long period of time.

Swelling and shrinking are frequently characteristics of clay soils which preclude their use as structural fill materials. The volume of clay soils tends to change as the moisture content changes, even though there is no change in the external load to which it is subjected. Such changes in volume are brought about by stresses set up by capillary action in the pores of the soil; an increase in volume is called swelling, and a decrease in volume is called shrinking.

Fill material must be installed and compacted correctly if it is to remain stable and provide the required strength characteristics. Normally, fill should be placed in level, even layers of 6" to 12" of depth. Each layer is compacted by hand tamping, mechanical tamping with one-man gasoline engine powered "whackers", or rolling with heavy specially cleated rollers called "sheeps foot rollers", or tractors equipped with cleated wheels. Each layer of compacted fill is usually tested to assure that the required degree of compaction or soil density has been obtained before proceeding with the placement of successive layers.

In addition to the scrapers or bulldozers usually used for placing fill, and rollers for compacting the fill, sprinklers are needed for adding water to the fill material as necessary. Water replaces much of the air in the voids in the soil, and, being noncompressible, produces a denser soil state for a given degree of compactive effort.

SOIL TESTING

During the placement and compaction of fill materials, various soils tests may be employed to monitor the effectiveness and acceptability of the structural fill operations.

The tests which are generally used have been standardized and published by the American Society for Testing and Materials (ASTM), and are described in this section.

The strength characteristics of compacted fill soils are related to the void ratio or dry density of the soil. Foe each type of fill material, there is a specific water content that will enable a certain void ratio or dry density to be achieved with the least amount of compaction or effort. The water content that will allow the densest compaction under a given compactive effort is known as the optimum moisture content. The optimum moisture content for fill soil materials is usually determined by the "Modified Proctor Test".

For the Modified Proctor (Compaction) Test, the test apparatus consists of (1) a standard brass cylinder mold with a machined base which forms a bottom for compacting soil in the mold, (2) a removable extension which fastens to the top of the mold to hold the soil during compaction, and (3) a standard hammer having a milled face and weighing 10 lbs. This equipment is illustrated in Figure 29-1-28, and is arranged to allow the hammer to free fall exactly 18 inches to the surface of the soil in the mold. The soil sample is placed in the mold in 5 separate "lifts" (or layers), and each lift receives 25 blows of the hammer. The test is repeated on additional samples of the soil, with additional water added to the soil sample each time the test is repeated. For each trial, the wet and dry densities. and void ratios are computed. The unit dry densities and void ratios are then plotted against water content for each sample, and the optimum water content estimated from the resulting curve. (Please refer to the next page for Figure 29-1-28.)

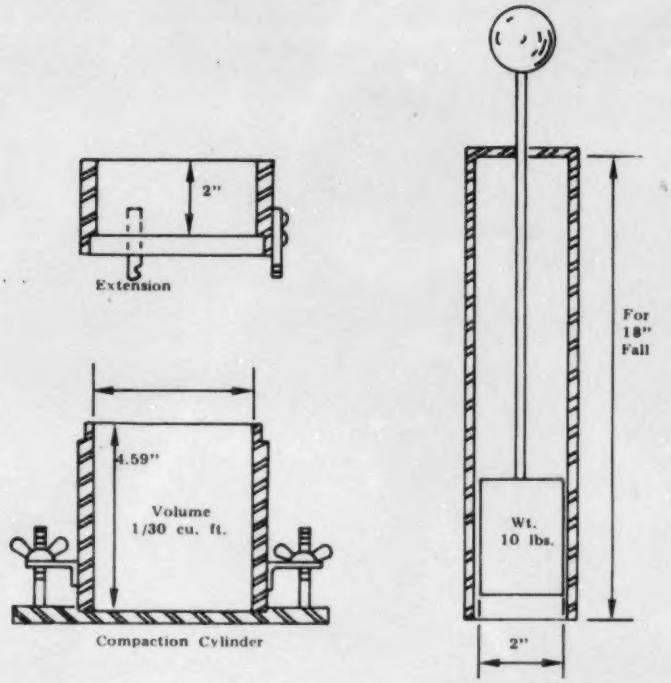


Figure 29-1-28 Modified Proctor (Compaction) Test Apparatus

As a general procedure, an experienced inspector on a project usually develops a "feel" for the soil being compacted and can tell by rubbing the soil in his hands and by observing the behavior of the soil under the operation of the construction equipment and the rollers whether the soil is too wet or too dry, or is at the desired moisture content. For example, if the soil springs under the roller and deflects a significant amount, the moisture content is too high. If the sheepsfoot rollers tend to ride out on the first couple of passes, the moisture content is too low. This ability to estimate moisture content in relation to

optimum is usually developed during the early periods of a job by making a large number of moisture-content determinations and correlating the results with the observed soils behavoir.

The compacted density of the soil may be determined in several ways. The most commonly used methods involve weighing a known volume of compacted soil. A more recent method is a nuclear technique utilizing a gamma source and a gamma detector. The nuclear method (ASTM Designation: D2922) involves placing the source and detector either on, into or adjacent to the material under test, measuring the transmitted or back scattered radiation, and correlating the results with a suitable calibration curve. The values obtained are expressed in units of total or wet density.

The technique of weighing samples is usually done by either the sand cone method (ASTM Designation: D1556) or the rubber-ballon method (ASTM Densignation: D2167).

The sand cone method consists of excavating a hemispherical hole in the surface to be tested, collecting the excavated material, weighing the excavated material, and determining the volume of the removed soil by pouring calibrated sand into the hole. The apparatus is illustrated in Figure 29-1-29, and consists of (1) a steel plate with a hole approximately 4 inches in diameter in the center, (2) a hollow cone which fits over this hole and with a fruit jar connection above, and (3) a 1-gallon fruit jar filled with calibrated sand (sand of uniform particle size and known density). Between the cone and the fruit jar there is a valve which allows sand to run down from the fruit jar into the cone below. Before using the apparatus, it must be calibrated to determine the unit weight of the sand in the jar, and the weight of sand which runs out of the jar in excess of that required to fill the cavity from which the soil sample was removed.

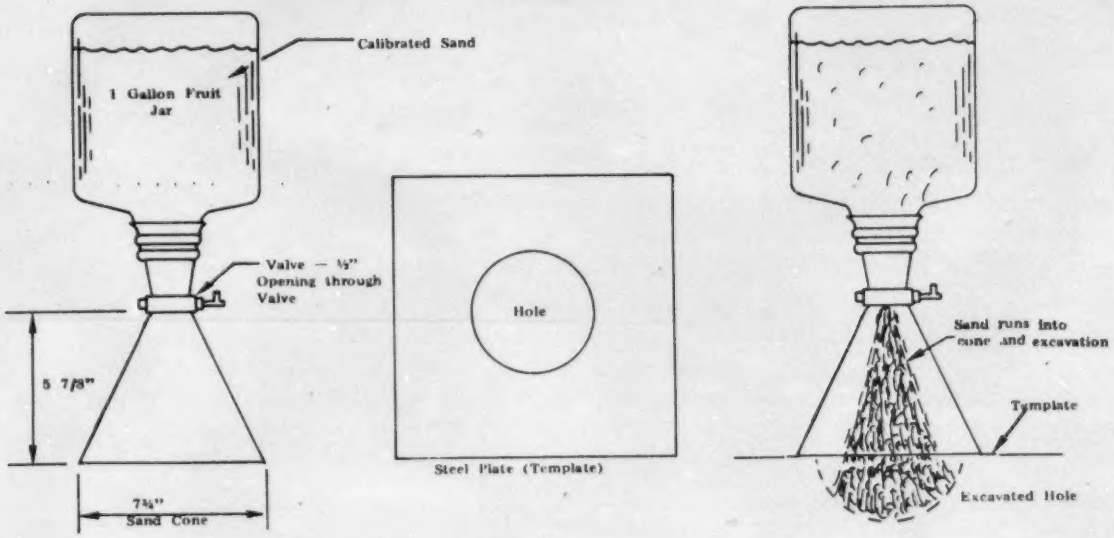


Figure 29-1-29 Sand Cone Density Apparatus

The rubber-balloon method consists of excavating a test hole, collecting and weighing the excavated material, and measuring the volume of the void by forcing water through the bottom of the test apparatus into a sealed latex balloon into the excavated pit. The apparatus is illustrated in Figure 29-1-30, and consists of (1) a steel plate (template), (2) a graduated glass or lucite cylinder enclosed in an airtight aluminum case with an opening in the bottom sealed by a balloon, (3) water in the cylinder, and (4) a double acting rubber bulb attached to the bottom of the cylinder for applying either a pressure or a vacuum to the inside of the cylinder with the apparatus positioned over the test location, the volume of water in the cylinder is read before and after the excavation is performed. The difference in volumetric readings represents the volume

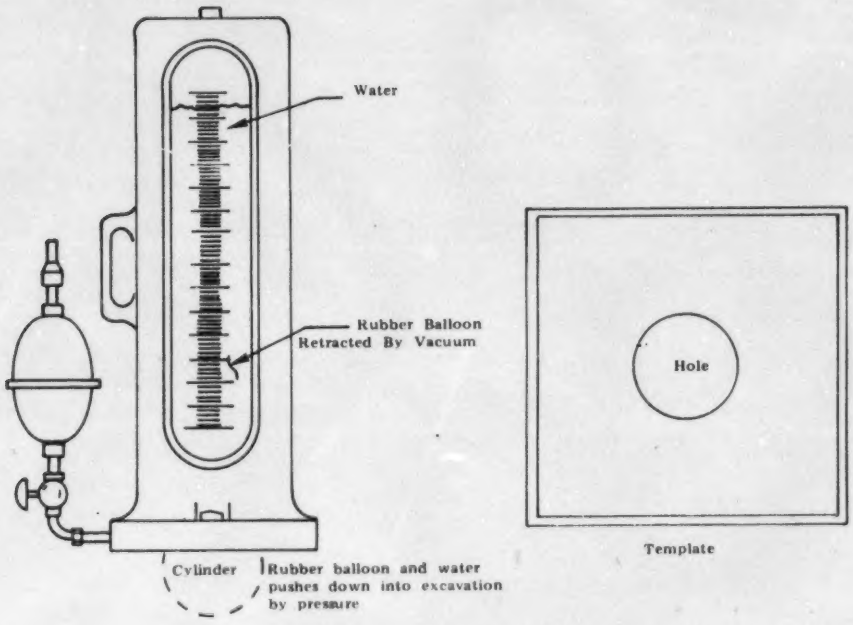


Figure 29-1-30 Rubber Balloon Density Apparatus

of the excavated test pit. The density of the fill material is then calculated from the test data.

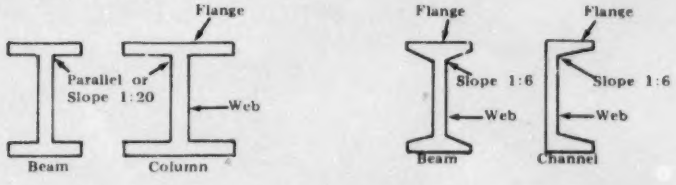
In all of these density tests, after the density is obtained, the value is compared with the maximum density obtained in the laboratory compaction test ("Proctor" test) to determine the percentage of (maximum) density. Layers that are not compacted to the specified percentage must be given additional compaction.

The QA/QC technician may function as an inspector for all fill, compaction, and soils testing operations. In this capacity, he may be required to:

1. monitor the fill material usage
2. monitor the proper placement of fill
3. monitor compaction techniques
4. perform appropriate compaction/density tests

STRUCTURAL STEEL ERECTION

The term structural steel is used to describe steel columns, beams, girders, trusses and other structural units used in building and bridge construction, which are fabricated by riveting, welding, or bolting together various types of rolled steel shapes or sections. Typical rolled steel shapes are illustrated in Figure 29-1-31.



Wide Flange Sections

American Standard Sections

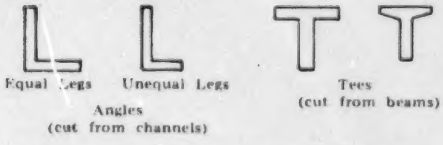


Figure 29-1-31 Types of Rolled Steel Sections

Structural steel members are usually prefabricated and delivered to the job site ready for installation. Care should be taken in unloading members, since poor practices such as using connection angles or plates for lifting points, or dragging members from trucks or flat cars from one end only may impose overstressing, resulting in kinks or misalignment. Members should not be dropped or impact loaded.

All fabricated steel members should be checked for size and shape against the applicable shop drawing before erection. The type of connectors should be reviewed before erection starts, and the members should be free of kinks, bends, and other distortions. Other checks that should be made before erection are:

1. surface preparation and coating, where required
2. proper milling of column ends, where required
3. proper holes sizes, number of holes, and layout of connections

Most field connections are now made with either high-strength bolts or welding. Before bolts are inserted, members are aligned and matching holes are brought into matching positions by means of one or more drift pins. A drift pin is a tapered steel rod which is driven into a hole. Poor connections with poorly matching holes are not acceptable, and are usually rejected.

Members which are connected by welding are aligned with welding clips and wedges, "come-a-longs" (portable geared winches with cables), and other devices.

Trusses are triangular shaped modules connected into a structural framework used to span large areas without intermediate support (supported at ends only). Large trusses may be shipped to a job site in sections, and are usually preassembled before erection. Lateral stability of trusses may be a problem, and, if handled roughly or improperly, will have a tendency to twist or bend sideways during erection.

Purlins are beams spanning from truss to truss, and are used for ceiling or roof construction. Purlins are relatively light shapes and must be handled carefully to avoid damage.

Bolting of structural steel is normally done only with high-strength bolts. The high-strength bolt is identified by three radial marks on the head and three long indented marks on the nut. The bolt is used with a washer on the side of the element that is turned, and all of the elements are made of high carbon steel. High tensile bolts are usually driven with precalibrated impact wrenches to the required torque value. It is considered good practice to inspect bolt installation and check the bolt tension of between 5% and 10% of the installed bolts, with a separate calibrated wrench. High-strength bolts should not be reused, since they do not develop design strength in this situation.

As erection work progresses, lower members are "plumbed", and their connections tightened. Permanently bolted connections should have a bolt in each hole, and heavy members temporarily fastened should be held with at least four bolts. Final operations include the removal of guy wires used for supporting and plumbing during erection, final inspection of connections, and the removal of temporary safety devices, such as railings, nets, scaffolds and planked floors.

The QA/QC technician may function in the capacity of a steel erection inspector. The following list summarizes the various items that he may check or inspect during the various erection operations:

1. check prefabricated members for shape, size and configuration
2. check shop painting for proper covering, scale, rust, and abraded areas
3. monitor contractor's lifting and handling operations of prefabricated members
4. monitor plumbing and bolt-tightening operations
5. inspect bolted connections

6. inspect high-strength bolting with calibrated wrench for proper torquing
7. review the test calibration of high-strength bolt wrenches on a daily basis

EXERCISES

1. A nuclear power plant is planned to be built on a site with the following characteristics:
   a. Area flat, lightly forested with heavy undergrowth.
   b. Elevations: existing ground level - 100'
      water table - 88'
      shelf rock - 80'
      lowest excavation - 60'
   c. Soil type: sandy, highly permeable.

   Listed below are various construction operations which are usually performed prior to concrete placement. Number the operations starting with "1" in the chronological order in which they typically occur:

   ____ connection of utilities
   ____ dewatering
   ____ grubbing
   ____ access road construction
   ____ established safety program - medical, fire protection
   ____ temporary construction buildings
   ____ excavation
   ____ logging, tree removal
   ____ railroad siding construction

____ swamping
____ top-soil removal
____ parking lot construction

2. The design mix for a particular batch of concrete requires the following materials:

water	325 lbs.
cement	550 lbs.
coarse aggregate (1")	1900 lbs.
fine aggregate	1200 lbs.

The batch plant has the following scale capacities:

water	2000 lbs.
cement	2500 lbs.
coarse aggregate (1½" or smaller)	6000 lbs.
fine aggregate	5000 lbs.

a. Calculate the batcher tolerance for each scale, based on scale capacity:

water	_____
cement	_____
coarse aggregate	_____
fine aggregate	_____

b. Calculate the batcher tolerance for each scale, based on batch weight:

water	_____
cement	_____

coarse aggregate _____

fine aggregate _____

3. A concrete batch plant is rated at a nominal output of 200 cubic yards per hour. For a particular placement of 1600 cubic yards, the following design mix will be used:

Water	350 lb./yd.^{3}
Cement	600 lb./yd.^{3}
Coarse Aggregate	1,800 lb./yd.^{3}
Fine Aggregate	1,300 lb./yd.^{3}

At the nominal output rate of the plant,

a. How much time is required to batch the concrete for the placement? _____

b. What is the hourly rate of usage of each of the component materials?

Water _____

Cement _____

Coarse Aggregate _____

Fine Aggregate _____

c. What is the total quantity of cement needed?

_____

4. List 5 factors that should be observed during concrete placement operations which affect the ultimate strength of the concrete.

5. Describe the concrete curing process, what occurs, and why curing procedures are necessary.

6. Explain where slip forms are generally used.

7. What are prefabricated panel forms used on large projects for wall construction?

8. What is the purpose of the concrete cover over the re-bar?

9. Improper welding on re-bar may produce a "notching effect". Explain how this affects its strength.

10. Does the tying of re-bar add strength to the structure? Explain.

11. Explain what is meant by the "Honeycomb" which may occur in concrete.

12. Name two general classes of soils and give two examples of each.

13. What characteristics of clay make it a poor structural fill material.

14. What is the usual recommended procedure for placing and compacting fill?

15. Why is the moisture content of fill so important?

16. What test can be used to measure soil compaction, with the results expressed as a percent maximum density?

17. Describe the physical difference between a typical wide flange beam section and a similar sized American Standard beam section used in structural steel construction.

18. Why are calibrated wrenches used to tighten high-strength bolts?

19. Visit a construction site where clearing and grubbing operations are taking place. Prepare a report as described in Procedure #1 of the Procedures section of this module.

20. Visit a concrete company which uses a stationary mixer. Prepare a report on your visit as described in Procedure #2 of the Procedures section of this module.

MATERIALS

None.

PROCEDURES

1. Visit a construction site as requested in Exercise #20 where clearing and grubbing operations are taking

place. Prepare a report including the following information:

a. Data
b. Site Location
c. Type of plant or building currently under construction
d. Description of any excavation and grading work
e. Type of equipment employed in excavating
f. Check conformance to such site drawing requirements as location, elevation, slope, and removal of loose materials
g. Description of any de-watering and drainage operations taking place
h. Any discussions with construction foreman or QA inspectors at the plant site.

2. Visit a concrete company as requested in Exercise #21 which uses a stationary mixer. Prepare a report on your visit which includes the following information:

a. Data
b. Location of cement company
c. Examination of cement batcher
d. Examination of aggregates
e. Amount of water added to a given batch
f. Description of batching equipment (manual, semi-automatic or automatic)
g. Any discussion with plant personnel, foreman or QA inspectors.

DATA TABLE

None.

REFERENCE MATERIALS

ACI Manual of Concrete Practice, American Concrete Institute, Detroit, MI

Materials Design and Control of Quality Concrete, Protex Industries Inc., Denver, Colorado

Control of Quality of Ready-Mixed Concrete, National Ready-Mixed Concrete Assoc., Silver Spring, MD.

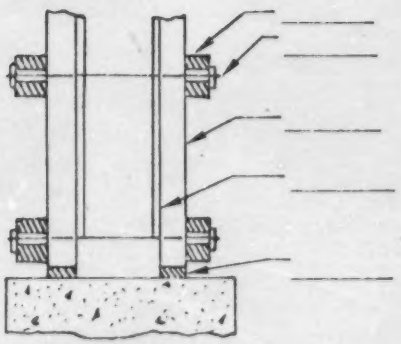
Placing Reinforcing Bars, Concrete Reinforcing Steel Institute, Chicago, Illinois

TEST

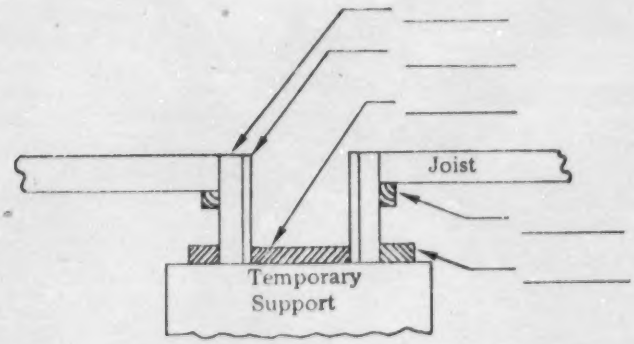
A. Complete the following statements:

1. Concrete derives its strength from _____.
2. A central mixing plant has the advantage of providing better control of the addition of _____ _____.
3. Transit mixing provides better control of _____ _____.
4. The simultaneous loading of dry concrete materials in a mixer is called _____.
5. Operator skill is most important in the operation of _____ batchers.

B. Label the indicated parts on the forms below:



Wall Form Section



Beam Form Section

C. Mark the following statements true or false:

____ 1. Slip forms are usually used for horizontal decks.

____ 2. Concrete slabs may be cast on elevated sheathing-type forms.

____ 3. Cleanout doors or panels are usually provided in column forms for removing concrete which fails to harden.

____ 4. Prefabricated panel forms are used on large projects for wall construction.

____ 5. Snap ties are frequently used to secure side panels to wales.

____ 6. The wall form sill is usually the last form component to be installed.

D. Complete the following statements:

1. Concrete cover over re-bar protects the steel from _____, _____ and _____.
2. Reinforcing steel is used to strengthen concrete in areas which are in _____.
3. The minimum concrete cover usually required for re-bars installed in slabs is _____.
4. _____ are used to support re-bar at the proper elevation and position in concrete forms.
5. Precast concrete blocks are usually installed in contact with the _____ and the _____.
6. Improper welding on re-bar may produce a _____ _____.
7. The "tying" of re-bar does not add _____ to the structure.
8. Using standard practice in placing bars in a floor slab, a bar designed to be located 2" from the form should fall between the dimensions _____ _____.
9. Tension cracks are most likely to occur in a concrete slab on the _____ side, between structural supports.

10. Proper positioning of re-bar in concrete, is critical to the _____ of that part of the structure.

E. Mark the following statements true or false:

____ 1. Forms should always be removed as soon as possible to minimize sticking, especially in cold weather.

____ 2. Partially cured concrete is known as "green" concrete.

____ 3. "Honeycomb" may occur when concrete is poorly mixed.

____ 4. Surface blemishes on stripped concrete are usually chipped out and repaired.

____ 5. "Sand streaking" may result when coarse aggregate is inadequately puddled with cement and water.

F. Answer the following questions:

1. Name two general classes of soils, and two examples of each.
2. The variability in soil densities is caused by what factor?
3. Clay soils usually make poor structural fill material due to what characteristics?
4. What is the usual recommended procedure for placing and compacting fill?
5. Why is moisture content of fill soil important?

G. Mark the following statements true or false:

____ 1. The optimum water content of soils for the densest compaction is usually determined by the Modified Proctor Test.

____ 2. The rubber balloon test is used to measure soil compaction, with results expressed as % maximum density.

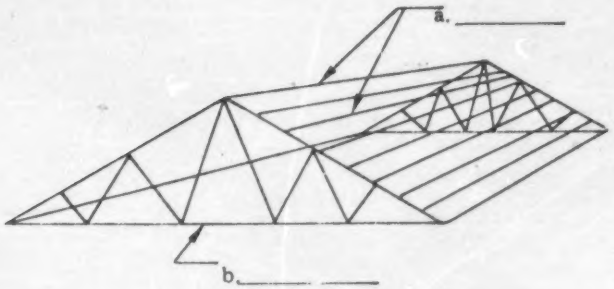
____ 3. In performing the sand cone test, a test hole is excavated and the excavated soil is discarded.

____ 4. An advantage of the sand cone test is that no calibration is required.

____ 5. In performing the Modified Proctor Test, the operator should carefully fill the compaction cylinder and the extension before compaction begins.

H. Answer the following questions:

1. Identify the indicated parts in the simple structure shown below:



Roof Structure

2. Describe the physical difference between a typical wide flange beam section and a similar American Standard beam section.

3. _____ are frequently used in aligning holes in mating steel sections during bolting operations.

4. How may high-strength bolts and nuts be identified?

5. Why are calibrated wrenches used to tighten high-strength bolts?

6. Mark the following statements true or false:

____a. The inspection of high-strength bolt tightening operations should include the physical check of the tension on a sample of the installed bolts.

____b. High-strength bolts are expensive and should be salvaged for re-use.

____c. When holes do not match in mating sections, it is acceptable practice to drill them out as large as necessary to accomodate the bolt.